Benefits of BlueSky for Air Quality Experts and Smoke Management Professionals

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Table of Contents

1 Introduction

Smoke from wildfire (both naturally occurring and prescribed) is a relevant concern for land managers and air quality professionals across the United States for a variety of reasons. Wildfire smoke poses a significant public health risk due to its high concentration of fine particulate matter (PM 2.5). These small particles embed themselves deep into human lung tissue, exacerbating existing respiratory conditions and potentially causing the onset of conditions for young children and the elderly (cite PM impacts studies). Another concern is that smoke often significantly reduces visibility, which can cause traffic accidents, generate unwanted haze in nearby cities or airports and negatively impact air quality in environmentally protected areas such as national parks. In addition to increased health costs, prolonged smoke events can negatively affect the local economy of small towns that rely on tourism and scenic attractions as visitors either cut trips short or cancel visits all together.

For these reasons, fire scientists and public agencies have put significant resources into the creation of science-based models capable of estimating the concentrations of emissions generated by fires and forecasting where the smoke from a given fire will go. One such effort is the BlueSky modeling framework, which was created by the US Forest Service AirFire Research Team. The BlueSky framework combines computer models of fuel consumption, emissions, fire, weather and smoke dispersion to predict smoke effects from existing wildfires, prescribed burns and agricultural burns. Its primary uses are to aid fire management professionals in making decisions for conducting prescribed burns and issuing public health warnings related to wildfire smoke.

Based on regional smoke modeling work in the Pacific Northwest that began in 2001, BlueSky has been continually expanded and improved. In 2005, NASA's Applied Sciences Program awarded a grant to enhance the capabilities of BlueSky by:

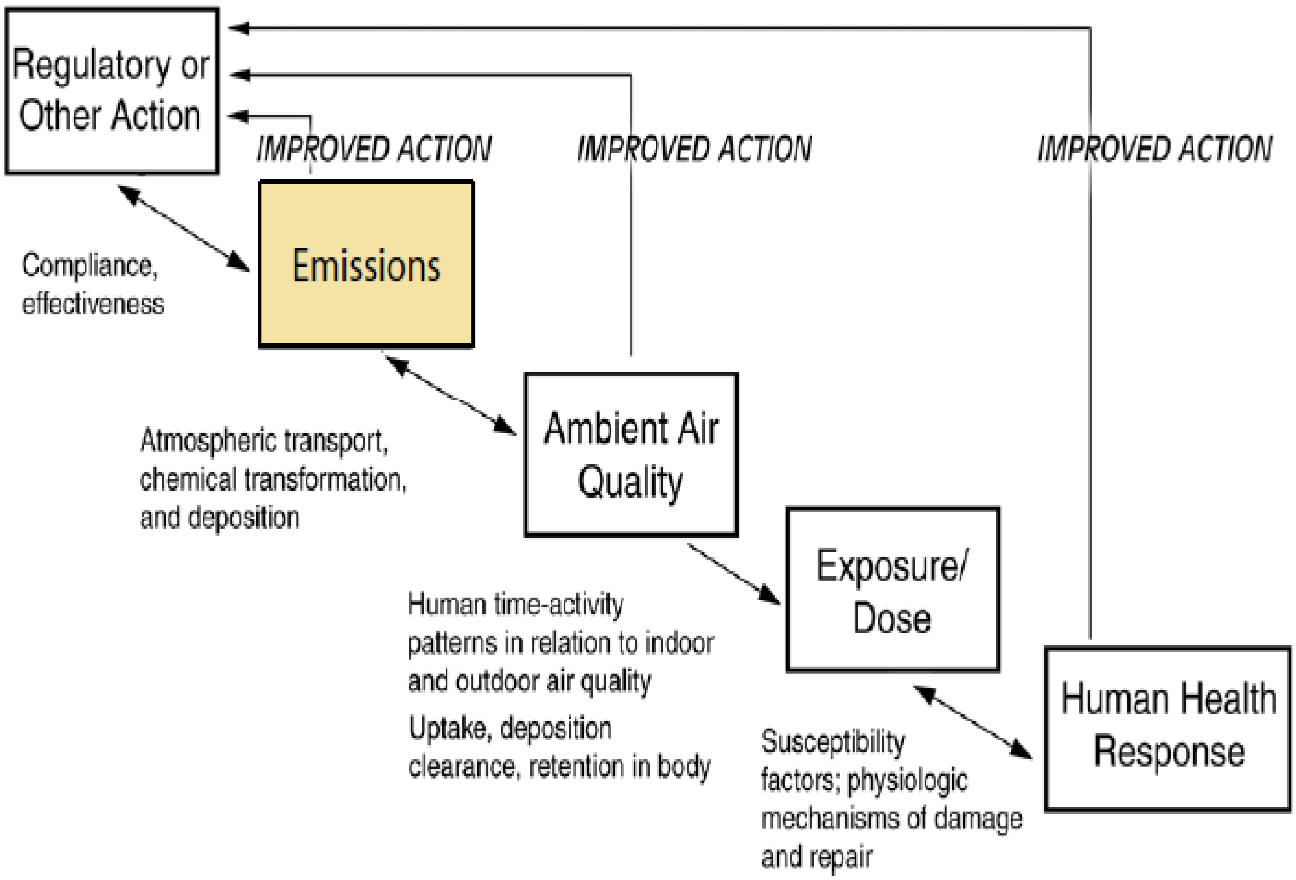
- incorporating NASA satellite data to improve accuracy;
- reengineering the framework to allow for modularity of the system,
- supporting maintainability; and,
- broadening the available model options for users.

The purpose of this project was to examine the socioeconomic benefits of NASA-enabled BlueSky that have been realized to date and provide quantitative estimates of those benefits to the extent possible. The project focused on two applications of BlueSky – preparing the wildfire component of the Environmental Protection Agency's (EPA's) national emission inventory process and using smoke forecasting to plan prescribed fires and issue public health warnings for wildfires. The primary sources of information used to assess the value of these benefits of BlueSky are telephone interviews conducted with EPA and USFS personnel.

1.1 National Emissions Inventory

The National Emissions Inventory (NEI) is a comprehensive and detailed estimate of criteria and hazardous air pollutants from all air emissions in the US. It is prepared every three years by the EPA. The NEI is used to support regulatory analyses; large-scale air quality analysis, emissions and climate change assessments; analyses of emissions trends; and international reporting (NEI 2008). The NEI is the primary source of data for determining each county's compliance with the National Ambient Air Quality Standards (NAAQS) and plays a central role in reducing negative health impacts associated with air pollutants (Figure 1-1).

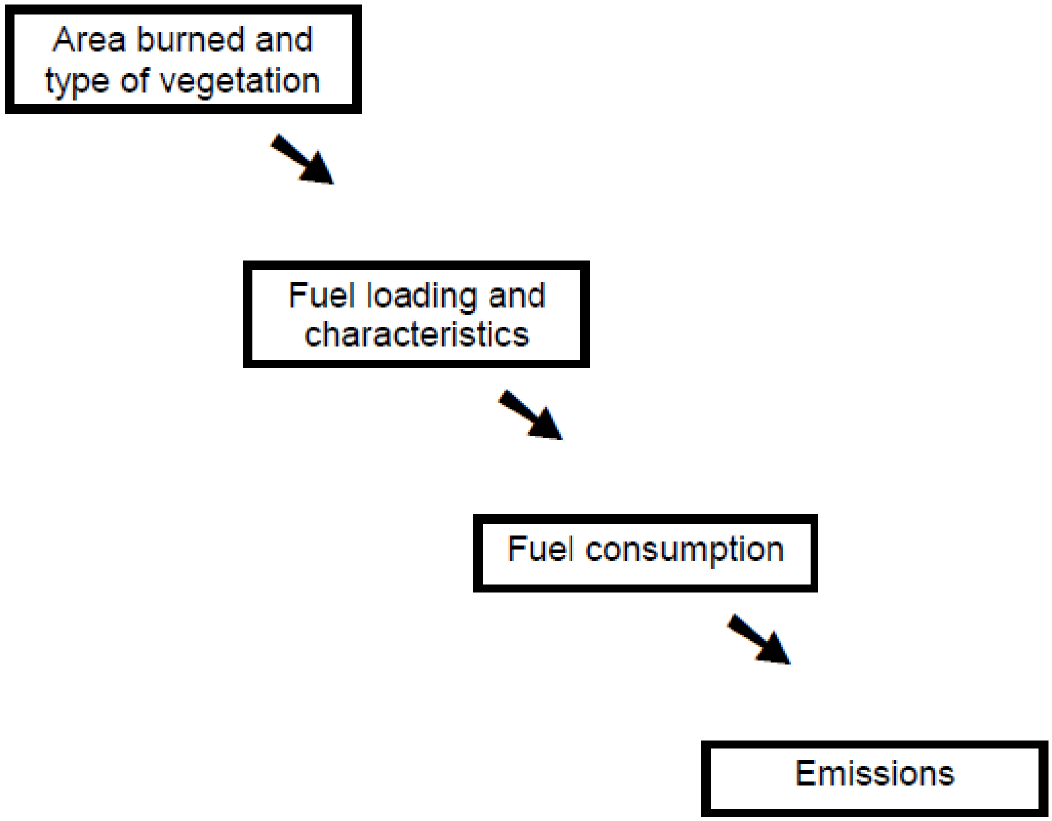
Figure 1-1: Role of Emissions in Air Quality to Health Effects Paradigm



Source: EPA (2013)

Emissions from fires are included in the NEI as their own sector that includes wildfires, prescribed burns and agricultural fires. In order to estimate emissions from fires, information is needed on the amount of fuel consumed, which is dependent upon the size of the area burned, the amount of fuel per unit area (fuel loading) and the characteristics and condition of the fuel. Fuels can include downed trees, fallen branches, decaying leaves and needles (duff), small trees or shrubs. Once the amount of fuel has been determined, emissions factors are applied to compute the amount of air pollutants emitted. A high-level summary of the process is provided in Figure 1-2.

Figure 1-2: Basic Process for Estimating Fire Emissions



Source: ECR (2002)

The emissions factors used to translate fuel consumption into emissions depend on fire conditions so that emissions of some pollutants are significantly higher under smoldering conditions than under flaming conditions. Because of this, many fuel consumption models also estimate the relative amounts of smoldering and flaming that will occur for various sets of fire conditions. The emissions calculations outlined above can be calculated for either individual fires or on an annual basis for multiple fires in a particular region.

1.2 Smoke Forecasting

Smoke forecasting is used by fire management professionals throughout the country for both wildfires and prescribed burns. States have primary responsibility for the cleanliness of the air and work with federal, regional, state, tribal and private land managers to help manage smoke. For large wildfires, forecasting models are generally used for tracking purposes and to help inform public health warnings. One of the primary tools available for mitigating the risk of catastrophic fire is prescribed burning; however prescribed burns also produce smoke that must be managed. In addition to health concerns and the NAAQS, smoke also poses visibility risks for burns that are planned in the vicinity of populated communities, airports, schools, highways or protected airsheds such as national parks. Conducting a burn with poor ventilation conditions or winds blowing in the wrong direction can reduce visibility to essentially zero, especially during the night hours. Because many of these negative impacts involve the public, land managers also must be able to communicate potential smoke impacts to the general public and protect themselves from lawsuits that may arise due to poorly managed smoke.

The basics of smoke movement are well understood – air and smoke move upwind and upslope during the day and downslope and downwind at night. Large smoke plumes are carried by the wind and can travel for many miles downwind. More difficult to predict is what exact concentrations will be in different locations and what will happen to the smoke as it moves further from the source of the fire. In addition to data on fires and fuels, smoke forecasting models also utilize weather and terrain data since winds are strongly influenced by topographic features like mountains, valleys and gorges. A full characterization of a smoke plume requires an understanding of the wind patterns (both horizontal and vertical), humidity, temperature and stability within the air column (PNW 2006).

1.3 Existing Models

Fire science is relatively young as a scientific field of study, but has seen significant development over the course of the past two decades. In 1998, the US Congress created a funding authority to increase the use of fire and mechanical fuels treatments as management tools with the goal of reducing the risk of severe wildfires. This initiative included the creation of the Joint Fire Science Program (JFSP), which was responsible for providing a scientific basis for the management activities and supplement existing fire research capabilities. Members of the JFSP include the Bureau of Land Management (BLM), Bureau of Indian Affairs (BIA), National Park Service (NPS), Fish and Wildlife Service (FWS), U.S. Geological Survey (USGS) and the Forest Service (USFS). The JFSP continues to pursue this mission today and also serves as a clearing house for funding opportunities as well as current and completed research projects.[1]

Much of the development and growth of fire science has manifested itself in the form of computer models that are capable of tracking existing fires and forecasting smoke impacts. There are currently tools available to model a variety of different aspects of the relationship between wildfire and air quality, including atmospheric conditions affecting smoke, smoke concentrations, ventilation indices, current air quality conditions, smoke trajectories, fuel consumption, fuel loadings, plume rise and fire emissions.[2] In addition to tools and resources that are available nationally, there are also regional programs that aim to assist fire managers in a specific part of the country. Examples of these initiatives include the AirFire Research Team, the Western Regional Air Partnership (WRAP) and the Southern High Resolution Modeling Consortium (SHRMC). Each of these organizations has also developed a suite of modeling tools for different aspects of smoke management.[3]

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[1] For more details on the history of the JFSP, see http://www.firescience.gov/JFSP_plan.cfm

[2] Many of these tools are listed on the Wildland Fire Decision Support System (WFDSS) Air Quality Tools Portal - http://firesmoke.us/wfdss/

[3] For a list of tools that each organization promotes, see http://www.airfire.org/data/, http://www.wrapfets.org/ and http://shrmc.ggy.uga.edu/smoke/.

2 BlueSky Capabilities

The focus of this study is on a set of recent improvements made to BlueSky through NASA funding. BlueSky traces its roots to the atmospheric science research of Sue Ferguson in the Pacific Northwest during the late 1990's. It is not a single model, but rather a modeling framework that aims to capture the full complexity of all factors affecting long-distance smoke movement by drawing on several different models of weather, fire behavior, fire emissions, dispersion, and trajectory. The essential inputs for BlueSky are fire location and size, fuel load data, fuel moisture and weather conditions at the location of the burn. Using this information, several individual models interact with each other to produce estimates of total fuel consumption, emissions, plume transport and smoke dispersion (Table 2-1).[4]

Table 2-1: Models Incorporated into the BlueSky Framework

Fire Information	Fuels	Total Consumption	Time Rate	Emissions	Plume Rise	Dispersion/ Trajectory	Meteorology
SMARTFIRE	FCCS	CONSUME 3	Rx/WF	FEPS	Briggs	CalPuff	MM5
ICS-209	NFDRS	FOFEM	FEPS	EPM	Multi-core	HYSPLIT	WRF
Rx Sys	Hardy	FEPS	FOFEM	FOFEM	Daysmoke	CMAQ	NAM
	LANDFIRE	EPM	EPM			GEMAQ	NARR
		ClearSky	WRAP				
		Satellite					

In 2005, NASA's Applied Sciences Program awarded a three-year grant to enhance BlueSky's capabilities. Several key improvements were made to the existing BlueSky Framework, including:

- Broadening the available model choices and allowing for modular runs of individual models
- Developing the Satellite Mapping Automatic Reanalysis Tool for Fire Incident Reconciliation (SMARTFIRE) for integrating satellite-detected fires with ground-based reports and preparing fire activity data for input to BlueSky
- Ability to generate output data products that are formatted for emission inventory use
- Set up BlueSky gateway to provide access to predictions of air pollutant concentrations, emissions estimates and fire information for near real-time and retrospective applications

These improvements were specifically designed to expand BlueSky's capabilities to improve the quality of the decision-support tools available in the framework and expand its coverage to the entire U.S. The improvements simultaneously improve its existing smoke forecasting capabilities and allowed the BlueSky framework to be used to support the National Emissions Inventory.

[4] A detailed technical description of BlueSky's capabilities is not necessary for the purposes of identifying its benefits and so this report focuses on high-level functionality and uses.

3 Benefits of NASA-enabled BlueSky

To assess the benefits of the improvements to BlueSky made through the NASA grant, there are three general questions of interest:

- To what extent is BlueSky being used for the purpose under consideration?
- What are the costs of the current set of processes involving BlueSky and what are the associated benefits?
- What are the costs of the processes that would have been undertaken without the NASA enhancements and what are the corresponding benefits?

Quantitatively measuring all of the benefits of BlueSky poses a significant challenge, primarily due to the fact that many benefits involving clean air and improved information are non-market goods that have only indirect relationships to goods and services that are incorporated into markets and have associated prices. Techniques for estimating the value of these “non-market” goods do exist[5], but they typically require a significant amount of micro-level data that is costly and time consuming to obtain and may potentially not exist at all. Further complicating a complete cost-benefit type analysis is that establishing a valid counterfactual for comparison with a current process can be difficult outside of an experimental setting. Previous work has estimated the benefits of BlueSky for prescribed burning and human health in California and Canada using extensive fire impact data (NASA 2011, Yao et al. 2013).

For the reasons listed above, this report focuses on measuring benefits for two specific applications of BlueSky – cost savings that result from using BlueSky for the NEI and efficiency gains by smoke forecasters. The primary sources of data used to estimate these benefits are detailed interviews conducted with EPA staff that prepare the NEI and fire management professionals including land managers, fuels specialists, air quality specialists and prescribed fire planners (“burn bosses”) from state and federal agencies. Over 20 interviews were conducted over the phone with subjects from across the U.S. – Alaska (1 interview), Arkansas (1), North Carolina (2), California (6), Oregon (5), Washington (2), Idaho (1), Rhode Island (1), Florida (1), Colorado (1) and Montana (1). The interviews formed the basis for determining the counterfactual processes that would take place if NASA-enabled BlueSky did not exist and were also used to identify and confirm expected benefits. Information from interviews was supplemented with secondary datasets that provided more detailed information on costs associated with particular activities.

3.1 Wildfire Component of National Emissions Inventory

To evaluate the benefits of BlueSky related to the preparation of the NEI, phone interviews were conducted with staff members at EPA who are responsible for providing the estimates of fire emissions that go into the inventory. The EPA used NASA-enabled BlueSky to help prepare updated versions of the 2002 and 2005 NEI as well as the 2008 and 2011 versions. Interviews focused on EPA’s process for creating the NEI, the role of BlueSky in that process and how the NEI would have been conducted in the absence of BlueSky.

[5] For further reading on non-market valuation techniques related to environmental goods, see Haab and McConnell (2002) or Champ, et al. (2003)

Because wildfires are managed at the state level, EPA works closely with state and regional agencies to come up with fire emissions estimates. In many western and southeastern states where wildfires and prescribed burns are common, there are significant amounts of expertise and resources dedicated to fire management. The U.S. is divided up into 7 regional planning offices (RPOs) for air quality and one such organization, the Western Regional Air Partnership (WRAP) has been particularly active in developing capabilities for estimating and reporting fire emissions. WRAP uses fire emissions to support real-time decision making for smoke management and other air quality planning initiatives. Historically, WRAP has calculated the fire emissions manually for each of its individual member states and submitted them to EPA for inclusion in the NEI. Since 2007, WRAP has been developing a specific tool called the Fire Emissions Tracking System (FETS) to manage and organize fire data and perform the emissions calculations on a fire-specific basis. Beginning in 2011, WRAP began work to develop the capability to generate state and tribe-specific fire emissions files from the FETS, provide states and tribes the ability to review and supplement the files and ultimately submit the estimates to EPA for inclusion in the NEI.

Other states, however, do not have such resources available and rely on EPA to generate the emissions estimates that will be included in the NEI. For these states, EPA has historically relied on ground-based data made available by state and federal agencies and relatively crude techniques to make the emissions calculations. BlueSky has improved the calculations for these states by supplementing the ground-based data with satellite data via SMARTFIRE to both verify the size of reported fires and detect other fires. The models embedded in BlueSky offer an improvement over the older methods that were previously used to produce estimates of fuel consumption and emissions for detected fires. Fire detections and emissions estimates from BlueSky have been shown to provide useful model performance for specific case studies in California (Sullivan, et al. 2009), though some other case studies highlight situations where emissions estimates from FETS and BlueSky differ significantly (Mavko et al. 2012). Comparing different fire and smoke models to evaluate accuracy and further improve model performance is an active area of research (Larkin, 2012).

The value of NASA-enabled BlueSky for preparing the wildfire component of the NEI has been to give the EPA a tool that can be used to generate standardized preliminary estimates of fire emissions for all 50 states. These preliminary estimates are shared with the states, who then have the opportunity to either accept the estimates as-is, edit/supplement the estimates or replace them altogether using their own data. Before the 2002 inventory, wildfire emissions were estimated in a very crude manner that relied on incomplete data and broad assumptions regarding fuel consumption, fuel type and burning conditions. BlueSky represents an improvement in all of these areas and has been used to help prepare both wildfire and agricultural emissions inventories for all NEI versions from 2003-2011. The cost of using BlueSky to produce these estimates is approximately $39,000 per inventory in present value (i.e. 2014 dollar) terms[6].

To quantitatively assess the benefits associated with the use of NASA-enabled BlueSky, it is necessary to determine what the costs of preparing the wildfire component of the NEI would have been without it. The best source of information for what these costs are likely to have been comes from an effort led by

[6] To allow for more fair cost comparisons, all historical costs were converted to 2014 dollars using the Consumer Price Index (CPI) from the U.S. Bureau of Labor Statistics (http://www.bls.gov/data/inflation_calculator.htm)

WRAP to prepare a national wildfire air emissions inventory for all five RPOs for the calendar year 2002. This Inter-RPO national emissions inventory was completed in September of 2005 and consisted of the following activities:

- Collection of fire activity data from RPOs, federal, Tribal and state agencies
- Development of data quality objectives
- Culling data from the database that did not meet the data quality objectives
- Devising fuel consumption and emission calculation routines
- Estimating emissions for flaming phase and long-term smoldering for all fire events
- Delivery of an emission inventory database and dispersion model-ready digital files

An explicit goal of the Inter-RPO effort was to potentially provide the NEI with a nationwide inventory for wildfires that was developed using a consistent methodology.

The Inter-RPO national emissions inventory effort was funded at a cost of approximately $336,000 in 2014 dollars. Because the inventory was based on the manual assembly of fire activity data, repeating the same methodology to produce subsequent inventories would have resulted in similar costs, though it is likely that the costs would diminish over time due to process improvements. Under a scenario in which the cost of each subsequent inventory decreases by 10%, the total cost of completing national inventories for 2005, 2008 and 2011 would have been about $820,000, compared to about $117,000 for using BlueSky. The cost savings to EPA in this scenario are approximately $700,000, which represents a benefit-cost ratio of about 6-to-1.

Another possible counterfactual would be to consider the costs of an RPO preparing emissions inventories for individual states and submitting those emissions estimates to EPA for the NEI. As a point of reference for this scenario, WRAP spent over $1.2 million from 2002-2008 (average annual value of about $171,000) to develop the inventories of fire emissions for its member states[7]. It is difficult to imagine exactly how this number would translate to RPOs in other regions of the country because of differences in the number of fires and the pre-existing infrastructure for collecting the required data, but for states and RPOs without well-established agencies to handle such tasks the costs are likely to be substantial. As a simplifying assumption, let the costs of developing emissions estimating capabilities for an RPO be proportional to the number of acres burned in that RPO. Using the acreage estimates from the 2002 Inter-RPO inventory (ECR 2007), the annual cost of preparing emissions estimates for all of the RPOs would be about $200,000, or $600,000 to prepare the 2005, 2008 and 2011 inventories. This estimate is likely conservative because non-WRAP states have less experience with estimating emissions than WRAP and the EPA would also still incur some costs to compile the estimates from each state. In this scenario, the benefits of NASA-enabled BlueSky have been approximately $483,000 with a corresponding benefit-cost ratio of about 4-to-1.

[7] Cost estimates for WRAP projects were obtained from Western Regional Air Partnership Work Plan Updates during the period 2001-2011.

3.2 Smoke Management Benefits

In addition to geographic coverage, the interviews with fire management professionals also covered a diverse group of organizations (see Table 4-1) that together are involved in almost all aspects of wildfire suppression and prescribed burning activities. Due to there being only a small number of organizations who manage these activities, a convenience sample was used with the goal of speaking with as many people in those organizations as possible during the study timeframe. Because of BlueSky's history of development in the Pacific Northwest, agencies in Washington, Oregon and California were oversampled relative to other parts of the country and are nearly comprehensive in their regional coverage.

Table 4-1: Organizations of Interviewees

Organizations Represented in Interviews	Organization Category	Number of Interviewees
US Forest Service	Burn Planner/Manager	5
California Air Resources Board	Air Quality	1
Arkansas State Parks	Burn Planner/Manager	1
Alaska Division of Forestry	Burn Planner/Manager	1
US Air Force	Burn Planner/Manager	1
US Fish and Wildlife Service	Air Quality	1
Bureau of Land Management	Burn Planner/Manager	5
National Park Service	Burn Planner/Manager	2
Rhode Island Department of Environmental Management Forest Division	Air Quality	1
San Joaquin Air Pollution Control District	Air Quality	1
California Department of Forestry and Fire Protection	Burn Planner/Manager	1
Oregon Department of Forestry	Air Quality	1

Due to the small sample size and exploratory nature of the interviews, questions were designed to be primarily qualitative in nature. Interviewees were all asked to describe their roles and responsibilities related to smoke management, how big of a priority smoke is in their area and the tools and models they used (if any) to perform their duties. After this initial set of scripted questions, participants were then specifically asked if they were familiar with BlueSky along with whether or not it was a tool that they use. If the participant uses BlueSky, they were asked to describe what they use it for and what benefits it provides to them. For those who did not use BlueSky, they were asked to identify reasons why or circumstances in which they would consider using it. Because the interview pool was known to be a very diverse group, the remainder of the interview was left unscripted and explored responses or topics that seemed most pertinent.

A primary application of the BlueSky framework is to aid in the planning of prescribed burns by forecasting where the resulting smoke will go under different conditions. Although there is some variation in the planning processes across different states[8], land managers (federal, state or tribal) map out locations and parameters for prescribed fires that they would like to conduct months in advance and submit those burn plans to a state air quality agency for approval. Each burn plan includes a date window for conducting the burn and is built around a set of meteorological conditions that are chosen to manage the resulting smoke and minimize any negative impacts that it could cause[9]. As the planned burn date approaches, meteorological conditions are closely tracked to identify exactly when the burn will be carried out. Ultimately, the state agency who issued approval of the burn has the final “go/no-go” decision about whether or not to carry out the burn.

For the land managers responsible for planning and carrying out burns (often called “burn bosses”), smoke is the most important dimension along which their plans will be evaluated. Almost all interviewees cited public health as the primary concern regarding smoke and other common motivations included keeping smoke out of Class 1 airsheds, avoiding non-attainment for PM, and avoiding visibility impacts for roads and airports. Though the state agency approves the burn, land managers are ultimately responsible for the smoke that is generated.

Historically, land managers have relied on the fuel characteristics at planned burn locations and meteorological forecasts as the primary data inputs to the prescribed burn planning process. Fuel characteristics including the type of fuel, moisture, and the amount to be burned are readily available by manually inspecting a proposed burn site, while meteorological parameters including wind direction, air temperature, humidity, wind speed and mixing height can be obtained from the National Weather Service[10]. Using these inputs along with an understanding of smoke transport to predict the qualitative dispersion and trajectory of smoke is a basic form of smoke forecasting that is used by all land managers that were interviewed.

As fire science and computing power have improved, researchers have worked to create modeling tools designed specifically for predicting concentrations of smoke emissions, how smoke plumes will disperse and where they will go. These tools range in sophistication, but aim to provide more accurate and detailed forecasts than can be achieved from using a forecast based solely on human judgment. Most are relatively new and are continuously in the process of being improved. The BlueSky framework incorporates several different smoke models that can be run in conjunction with other models or as individual modules.

The first thing to determine in assessing the benefits of BlueSky for smoke forecasting is estimating how much it is used. Of the 16 land managers interviewed, only two reported using BlueSky on a regular

[8] This variation reflects differences in the degree to which smoke is a concern in a given state as well as public sensitivity to smoke. In some states with a long history of burning, smoke sensitivity is low and the main concern is to maintain good visibility on roadways. Other states have sensitive airsheds and populations that are so averse to smoke that prescribed burning activities are under constant threat of being shut down.

[9] The most common burn seasons are during spring and fall months when fuel moistures and temperatures allow for fires to most easily be controlled.

[10] See http://www.srh.noaa.gov/ridge2/fire/ for more information on the tools and forecasts available.

basis and two others reported using other advanced modeling tools outside of the BlueSky framework. Despite the low number of users, all 16 interviewees said that they had at least heard of BlueSky. Several managers mentioned that they had used BlueSky at some point in the past and expressed a desire to learn more about it so that they could use it more frequently. There were a few factors given to explain the low level of usage. Most of those interviewed stated that they do not use any tools for advanced modeling on a regular basis because they either have access to modeling specialists and fire meteorologists who they rely on to perform advanced analysis or simply rely on the state regulating agency. Conflicting responses were obtained regarding whether or not managers thought their smoke plans were more likely to be accepted if some kind of advanced modeling was done.

Although only a few burn managers reported using modeling tools, discussion about how those tools are used can provide insights about the potential benefits. The features of BlueSky that users report using most regularly are the emissions estimating capabilities, the diurnal profile and the Google Earth overlay for displaying the forecasted smoke trajectory. For these managers, BlueSky is used during the initial development of burn plans well in advance of the planned burn date and detailed meteorological data is relied on heavily as the burn date gets closer. Advantages of BlueSky that were mentioned include greater transparency and a better platform for conducting sensitivity analysis. The other tools managers mentioned using outside the BlueSky framework include the VSmoke (http://webcam.srs.fs.fed.us/tools/vsmoke/VSMOKE_Interface.pdf) and SHRMC (http://shrmc.ggy.uga.edu/maps/screen.html) smoke screening tools, which were originally designed for use in the eastern part of the U.S.

In contrast to burn managers, air quality and fire specialists on the regulatory side of the prescribed burning process use BlueSky and other smoke forecasting tools more regularly. These specialized teams generally support burning activities for many land managers in multiple locations. A common theme during interviews was that multiple tools and information sources are used to determine the likely smoke impacts from a prescribed fire, including national weather models (e.g. NAM, GFS, MM5), BlueSky, HYSPLIT (both within and outside the BlueSky framework), in-house statistical models and on-site projections using data from monitoring stations. All modeling specialists interviewed reported that they use BlueSky in some capacity to aid in their decision making.

When specifically asked to evaluate the usefulness of BlueSky, respondents listed several positive attributes. The primary appeal of BlueSky is that it provides access to multiple models in one place and is capable of providing analysis specifically for smoke. Fine spatial resolution and visualization capabilities via Google Earth were given as benefits and one user also mentioned that BlueSky served as a valuable "language translator" that could effectively communicate the results from complex scientific models to the public. Air quality and fire specialists were also asked about their use of smoke models for wildfires and listed similar benefits and a demonstrated ability to handle large amounts of information.

In addition to these benefits, however, respondents also expressed some reservations. Most of the specialists stated that they didn't fully trust the accuracy of the results within BlueSky and cross-check results by looking at meteorology data. Another problem cited was a lack of timeliness that made using BlueSky for the evaluation of large numbers of prescribed burns difficult. These concerns have led to the assessment that advanced smoke dispersion models have certainly improved during the past decade, but need additional improvement and verification before they are ready to be used more regularly. As the models do continue to improve, the modeling specialists also feel that it is important that they coordinate with managers on the ground to provide consistent information to the public about smoke conditions.

4 Conclusions

This report analyzed the benefits of NASA-enabled BlueSky related to the preparation of the National Emissions Inventory as well as the planning and implementation of prescribed fires throughout the U.S. The analysis utilized information gathered from more than 20 in-depth interviews of fire management and air quality professionals that was supplemented by additional research on the costs associated with the preparation of fire emission inventories. Where applicable, benefits were estimated in monetary terms.

The NASA-enabled BlueSky framework has been used by the EPA to calculate and compile wildfire emissions for inclusion in the 2005, 2008 and 2011 (in progress) versions of the National Emissions Inventory. Using BlueSky allows EPA to estimate emissions for some states at lower cost than other available options to achieve a comparable level of accuracy, while also accepting data from states who prepare their own estimates. Based on the costs associated with the Inter-RPO 2002 national emissions inventory effort and other tools developed to assist in the preparation of fire emissions inventories, NASA-enabled BlueSky has provided an estimated $483,000-$700,000 in cost savings to the EPA. In addition to the cost savings, BlueSky has also improved the transparency of the emissions inventory process, which has eased tensions between EPA and states with regards to the accuracy of the total amount of emissions from fires in a given state.

BlueSky is one of several tools available to forecast smoke impacts from prescribed burns and is not widely used by burn managers and air quality professionals in regulatory agencies. Current benefits of BlueSky for smoke forecasting appear limited, but widespread knowledge of BlueSky and interest in learning how to use it suggest that the benefits are likely to increase in the future. Among the benefits cited by those who do currently use BlueSky are improved spatial resolution of smoke impacts compared to other tools and the ability to serve as a good vehicle for sharing smoke projections with the public via Google Earth. These users see additional potential value in its ability to streamline the smoke management process, but note that any widespread efficiency gains will depend on additional verification and trust in the accuracy of advanced models.

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